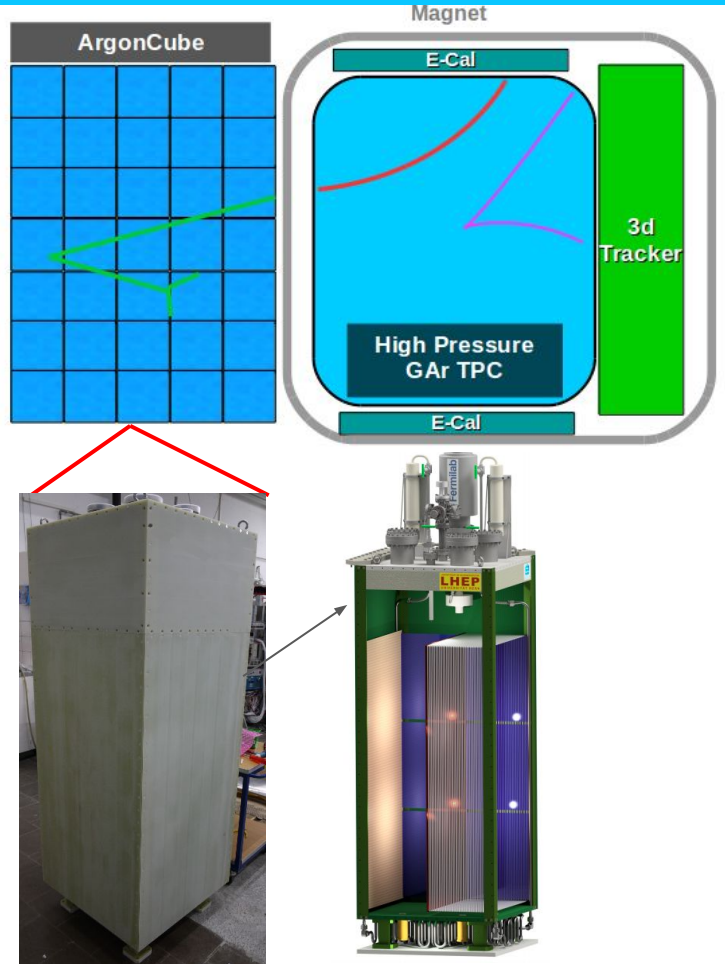
Overview of ArgonCube for the DUNE Near Detector

Jonathan Asaadi and Dan Dwyer

On behalf of the ArgonCube Collaboration

ArgonCube Concept (in one slide)



- **ArgonCube is the liquid argon TPC portion of the DUNE-ND design**
  - 5 m x 7 m x 3 m split into 35 independent modules
    - optimised for hadron containment and side-going muons
  - Each module is 1 m x 1 m x 3 m which operates two independent TPC's
    - Minimize Rayleigh scattering & diffusion
    - Reduces HV and purity requirements
    - Reduction of inactive materials between modules through use of resistive film field cage and thin G10 shell
  - TPC's will utilize new pixel based readout (LArPix) and novel light detection technology (ArcLight)
    - Area of active R&D with many technology demonstrations ongoing!

ArgonCube Collaboration

ArgonCube

An international collaboration for LArTPC R&D, with a focus on the technical needs for DUNE.

Current R&D

- Detector Modularization
- Pixelated charge readout
- Enhanced scintillation light readout

Applications

Primary: DUNE Near Detector LArTPC

May also lead to enhancements of the DUNE Far Detector.

Letter of Intent

ArgonCube: a Modular Approach for Liquid Argon TPC Neutrino Detectors for Near Detector Environments

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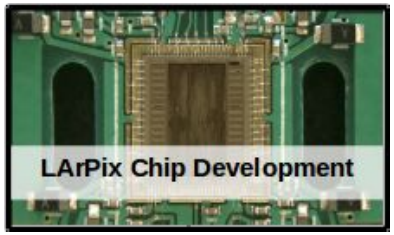
ArgonCube Collaboration

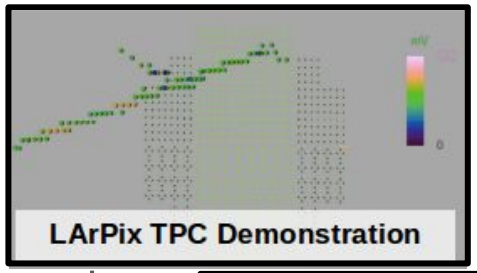
Collaboration Meeting
March 2019

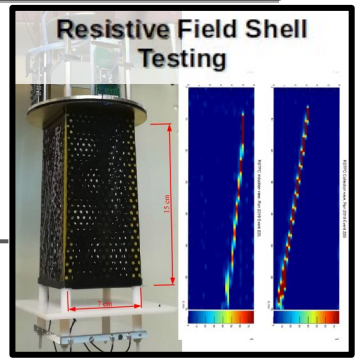
ArgonCube's Recent Work

There has been a long R&D history leading to the consideration of a LArTPC Pixel based detector as a component of the DUNE-ND

- There is also a lot of work still yet to do!

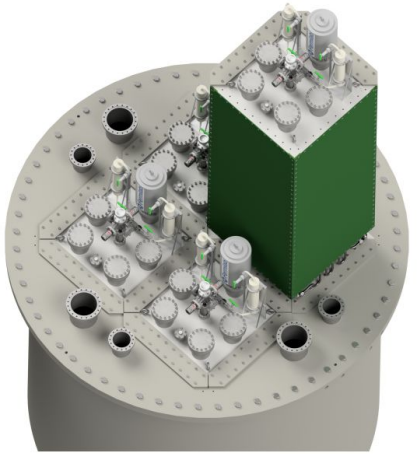






2016 2017 2018 2019

ArgonCube 2x2 Demonstrator



‘ProtoDUNE’ for the Near Detector LArTPC

Integrated test of ArgonCube technologies
4 independent LArTPC modules
Slightly smaller scale than ND: 0.7m x 0.7m x 1.4m per module
Goal: Guide DUNE Near Detector technical design, TDR

Status:

Cryostat commissioned
First module assembled, w/small TPC
Assessing LAr purification, module insertion/extraction

Targets:

Late 2019: Commission all 4 modules
2020: Operate in neutrino beam in NuMI near hall @ FNAL
Dec. 2020: Complete DUNE ND TDR

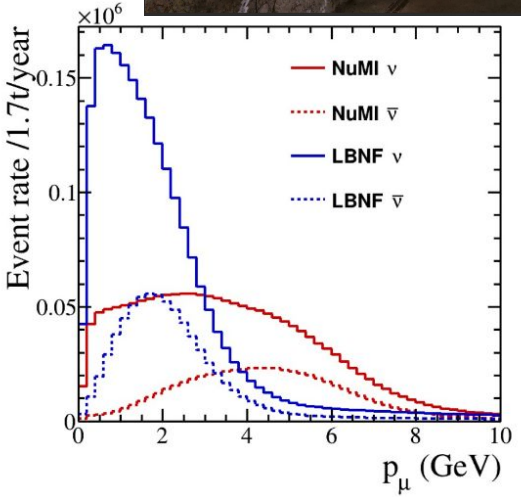
ProtoDUNE-ND in the NuMI Near Hall

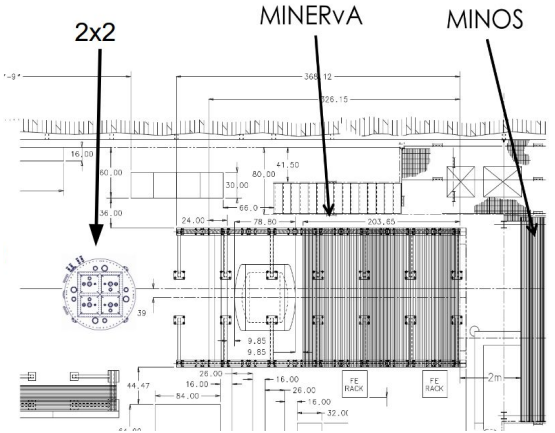
‘ProtoDUNE-ND’
Engineering demonstrators for DUNE Near Detector technologies

ArgonCube 2x2 Demonstrator:
Technical demonstrator for the LArTPC component of Near Detector

NuMI Near Hall:
Neutrino rates and energy spectrum similar to planned DUNE LBNF beam

Aiming for operation in 2020





ArgonCube: Opportunities

Two major tasks:

ArgonCube 2x2 Demonstrator:
→ Design, construction, operation, analysis, etc.
→ Lots of work to do, many opportunities

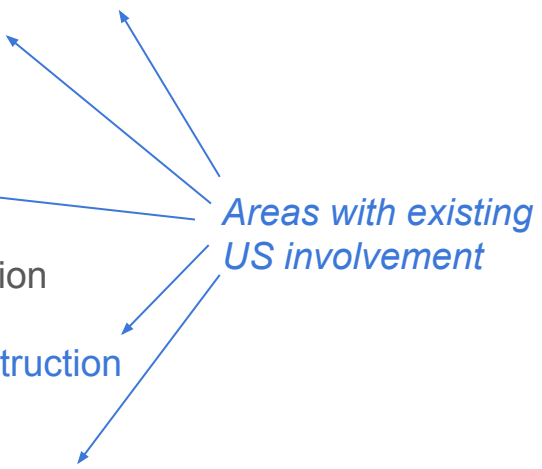
DUNE Near Detector:
→ Simulation and analysis to guide the integrated Near Detector Concept
→ ***Focus on physics studies needed!***
→ Incorporation of results from the 2x2 Demonstrator, refine the Near Detector Concept

Some example opportunities:

Hardware:
- Resistive field cage, cathode, HV
- LArPix charge readout
- Novel light readout
- Calibration systems
- Mechanical integration
- Cryostat, cryogenics
- Purification
- Monitoring instrumentation

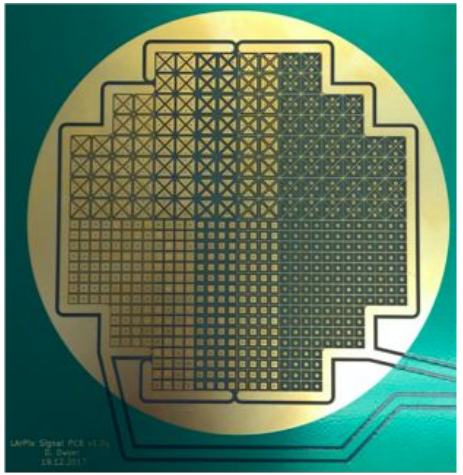
Analysis & Software:
- Pixel simulation, reconstruction
- Light system sim/recon

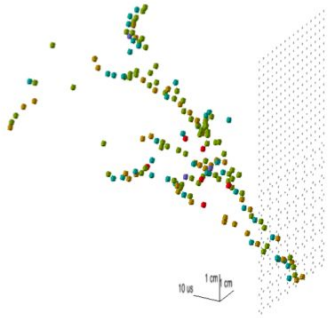
General:
- Commissioning, operation



Detailed Example: LArPix charge readout

ArgonCube 2x2 Demonstrator: Needs ~6 m^2 of pixel anode (>400k channels!)





Aggressive 2019 schedule:

Component testing:

1) Detailed characterization of the unpackaged LArPix-v2 ASIC (Jul-Aug)
2) Detailed characterization of the packaged LArPix-v2 ASIC (Jul-Aug)
3) LArPix-v2 ASIC qualification (Jul-Nov)
   Targets: Jul ~100-200 ASICs; Sep ~2000 ASICs; Nov ~8000 ASICs
4) Unloaded Pixel tile PCB qualification (Jun-Nov)
   Brief assessment of each PCB before component/ASIC loading.
   Targets: Jun ~5-10 small prototype tiles; Sep ~20 tiles; Nov ~100 tiles

Pixel tile testing:

1) Prototype tile testing (Aug-Sep)
   Test a small number (5 to 10) small-scale (~16cm x ~16cm, ~25 ASICs) prototype tiles using the v2 ASIC.
2) Initial full-scale tile testing (Oct-Nov)
   Test a moderate number (~20) of production scale (~32cm x ~32cm, ~100 ASICs) pixel tiles.
   Send to Bern and install in first 2x2 module.
3) Remaining full-scale tile testing (Nov-Feb)
   Test ~80 production scale pixel tiles to instrument the 3 other 2x2 modules, plus 1 spare module, plus ~10% spare tiles.
   Send to FNAL and install in the remaining 2x2 modules.

Detailed Example: LArPix charge readout

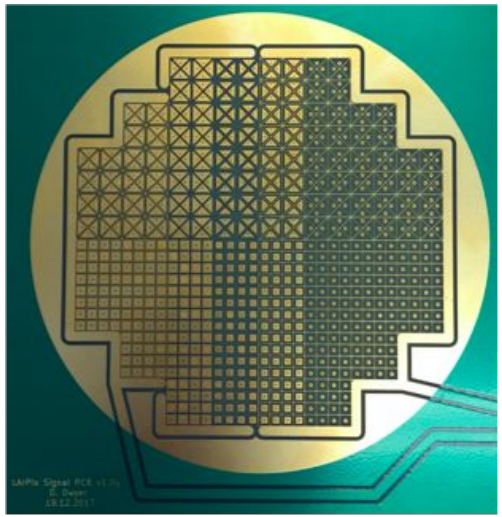
Even in this subsystem alone, plenty of opportunities

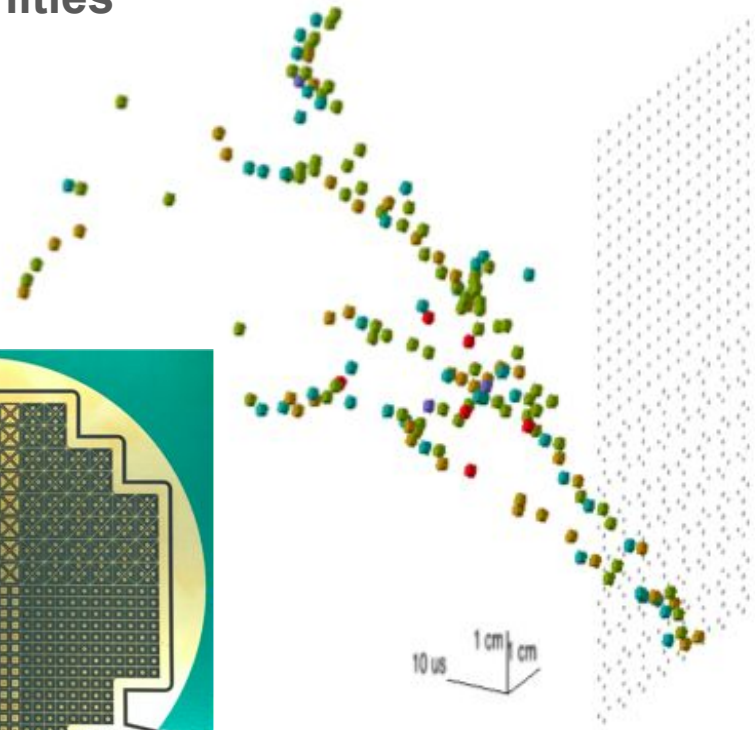
Pixel Tile Development:
- ASIC and pixel tile testing
- Detailed pixel tile characterization, ASIC tuning

Full Readout System Development
- Field cage interface
- Cabling, Feedthroughs
- Warm Electronics
- Clock
- Power supplies
- DAQ
- Slow Control / Configuration Mgmt

Pixel LArTPC Calibration

Pixel LArTPC Simulation and Analysis
- Software framework
- Algorithm development





ArgonCube: Summary

ArgonCube:

An international collaboration for LArTPC R&D, with a focus on the technical needs for DUNE.

Near term efforts:

Development, construction, operation of the ArgonCube 2x2 Demonstrator

Design studies to guide the LArTPC component of the DUNE Near Detector

→ ***Plenty of opportunities for additional partners!***